ARTIFICIAL TURF BACKING

Technical Field

The present invention relates generally to the field of artificial turf, and more particularly to artificial turf having an improved primary backing that includes multiple primary backing layers.

Background Art

In the past, artificial turf has been made by tufting synthetic grass fibers through a primary backing. The primary backing has generally been made of a layer of polypropylene material, either woven or non-woven, through which the artificial turf fibers are tufted. Typically, after the artificial fibers are tufted through the primary backing, the underside of the backing is coated with an adhesive to help secure the tufted fibers. Panels of the turf are then joined together to cover the desired area. However, turf systems known in the prior art still have problems with tuft bind, do not provide certain desired dimensional stability and biomechanical properties, and do not have long-lasting seaming strength.

Hence, it would be beneficial to have artificial turf which has a primary backing that holds turf fibers in the transverse direction while also providing lateral seaming support and desired dimensional stability and biomechanical properties.

Disclosure of the Invention

With parenthetical reference to the corresponding parts, portions or surfaces of the disclosed embodiment, merely for the purposes of illustration and not by way of limitation, the present invention provides improved artificial turf (15) comprising a primary backing (16) having a first side (52) and a second side (53) and comprising a first backing layer (23), a second backing layer (24), a third backing layer (25), and a fourth backing layer (26), a plurality of fibers (19) sewn through the primary backing, and a secondary backing on the second side of the primary backing. The first layer may facilitate tufting, the second layer may facilitate dimensional stability, the third layer may facilitate tufted bind and the fourth layer may facilitate seam strength. The fibers may form upstanding ribbons (17) on the first side of the primary backing and the turf may further comprise an infill layer

(20) disposed between the ribbons. The fibers may form a plurality of back stitches (27) on the second side of the primary backing and the secondary backing may cover the back stitches and lock in the fibers, and the secondary backing may be a urethane coating applied to the second side of the primary backing. The fibers may form a plurality of rows (49) and a plurality of columns (48) of ribbons, the distance between each of the rows being substantially the same as the distance between the columns. The artificial turf may comprise a first panel (36a) and a second panel (36b), the first panel having a first edge and the second panel having a second edge, the first and second edges sewn together to form a seam (40a), and the turf may further comprise seam tape (46) covering the seam on the second side of the primary backing.

Accordingly, the general object of the present invention is to provide artificial turf in which the tufted fibers are more securely held in place.

Another object is to provide artificial turf in which the fibers are not easily pulled free from the primary backing.

Another object is to provide artificial turf that has a primary backing that facilitates tuft bind.

Another object is to provide artificial turf which provides better lateral support for seaming.

Another object is to provide artificial turf that has a primary backing that facilitates seaming.

Another object is to provide artificial turf which has increased dimensional stability.

Another object is to provide artificial turf having beneficial cushioning characteristics.

Another object is to provide artificial turf having beneficial frictional characteristics.

These and other objects and advantages will become apparent from the foregoing and ongoing written specification, the drawings, and the appended claims.

Brief Description of the Drawings

Fig. 1 is a cross-sectional view of the preferred embodiment.

Fig. 2 is an enlarged detailed view of a portion of the embodiment shown in Fig. 1.

Fig. 3 is a bottom exploded view of a portion of the embodiment shown in Fig. 1, showing the construction of the primary and secondary backing.

Fig. 4 is schematic of the four component layers to the primary backing of the embodiment shown in Fig. 1, showing the weave of each layer.

Fig. 5 is a cross-sectional view of a first alternate embodiment.

Fig. 6 is an enlarged detailed view of a portion of the embodiment shown in Fig. 5.

Fig. 7 is a cross-sectional view of a second alternate embodiment.

Fig. 8 is an enlarged detailed view of a portion of the embodiment shown in Fig. 7.

Fig. 9 is a bottom exploded view of a portion of the embodiment shown in Fig. 7, showing the construction of the primary and secondary backing.

Fig. 10 is a cross-sectional view of a third alternate embodiment.

Fig. 11 is an enlarged detailed view of a portion of the embodiment shown in Fig. 10.

Fig. 12 is a bottom exploded view of a portion of the embodiment shown in Fig. 10, showing the construction of the primary and secondary backing.

Fig. 13 is a schematic view of a playing field made up of panels of the embodiment shown in Fig. 5.

Fig. 14 is a cross-sectional view of a prior art seam between two prior art panels of artificial turf.

Fig. 15 is a cross-sectional view of the seam between two panels of the embodiment shown in Fig. 13, taken on line 15-15 of Fig. 13.

Fig. 16 is a bottom sectional view of the seam between two panels shown in Fig. 13.

Description of the Preferred Embodiment

At the outset, it should be clearly understood that like reference numerals are intended to identify the same structural elements, portions or surfaces consistently throughout the several drawing figures, as such elements, portions or surfaces may be further described or explained by the entire written specification, of which this detailed description is an

integral part. Unless otherwise indicated, the drawings are intended to be read (*e.g.*, cross-hatching, arrangement of parts, proportion, degree, etc.) together with the specification, and are to be considered a portion of the entire written description of this invention. As used in the following description, the terms "horizontal", "vertical", "left", "right", "up" and "down", as well as adjectival and adverbial derivatives thereof (*e.g.*, "horizontally", "rightwardly", "upwardly", etc.), simply refer to the orientation of the illustrated structure as the particular drawing figure faces the reader. Similarly, the terms "inwardly" and "outwardly" generally refer to the orientation of a surface relative to its axis of elongation, or axis of rotation, as appropriate.

Referring now to the drawings and, more particularly, to Fig. 1 thereof, this invention provides an improved artificial turf system, the presently preferred embodiment of which is generally indicated at 15. Turf system 15 is shown as broadly including a base layer 22, a secondary backing 18, a primary backing 16, fibers 19, and an infill layer 20.

Turf fibers 19 are sewn or tufted through primary backing 16 such that ribbons 17 extend up from primary backing 16 and are designed to resemble grass. Where they are tufted through primary backing 16, turf fibers 19 form a plurality of back stitches 27 on the bottom side of primary backing 16. As shown in Fig. 3, turf fibers 19 are sewn or tufted through primary backing 16 in spaced rows 49 and columns 48 to form a grid of fibers 19. In the preferred embodiment, the distance 51 between rows 49 and the distance 50 between columns 48 is about three-eighths of an inch ("3/8). Thus, the spacing between the rows and columns of ribbons 17 on the top side of primary backing 16 is about the same. Having rows 49 and columns 48 equally spaced apart allows for a more consistent playing surface laterally and longitudinally. Turf fibers 19 are made of polyethylene with a face weight of 51 ounces per square yard.

Disposed upon the primary backing 16 and between ribbons 17 of turf fibers 19 is an impregnated or infill layer 20. In this embodiment, infill layer 20 is a uniform layer of 100% rubber particles, severally indicated at 21. The rubber particles may be ambient ground rubber or cryogenically processed rubber.

Primary backing 16 is evenly covered on its underside with a continuous secondary backing 18, which in the preferred embodiment is an urethane coating that helps secure the tufted fibers in place. Alternatively, a latex coating may be used. Secondary backing

18 is applied to cover the entire underside of primary backing 16. Where drainage is required, primary backing 16 and secondary backing 18 are pierced on four-by-three-inch centers to form discrete holes of approximately 0.375 inches or less in diameter.

Turf system 15 is installed by unrolling the primary and secondary backings 16 and 18, with fibers 19 tufted in place, over base layer 22. Thereafter, infill layer 20 is spread on the top surface of primary backing 16 and is raked into and between ribbons 17 of fibers 19 until only a portion of the ends of ribbons 17 are showing.

As shown in Figs. 2-3, primary backing 16 is formed from four distinct and stacked layers 23-26. Primary backing 16 is the material through which ribbons 19 are inserted. Secondary backing 18 is applied to the bottom surface of layer 26 and does not have ribbons 19 passing through it.

First layer 23 is a conventional woven, 11 pick plain weave that is commonly used in artificial turf. Layer 23 facilitates the tufting process and provides a matrix for tufting. In the preferred embodiment, layer 23 is 100% polypropylene with a weight of 3.05 oz./yd.^{2}. The PolyBac® style 2201 material manufactured by BP Carpet Backings, of 835 Shugart Rd., Dalton GA 30720, may be employed in the preferred embodiment.

Second layer 24 acts to provide dimensional stability by aiding in keeping primary backing 16 from contracting, expanding, stretching or elongating. Second layer 24 is less stretchable. Second layer 24 also acts to disperse impact energy over a surface area as great as three times the actual contact area, which results in less impact on and greater cushioning for players using the turf. In the preferred embodiment, second layer 24 is a spunlaid, nonwoven, thermally bonded fabric made from bi-component filaments having a polyester core and a nylon skin. The Colback® fabric manufactured by Colbond Inc. of P.O. Box 1057, Sand Hill Road, Enka, NC 28728, may be employed in the preferred embodiment.

Third layer 25 is a woven, 15 pick plain weave. Layer 25 assists in holding turf fibers 19 in place where fibers 19 extend through third layer 25. Layer 25 has numerous strands which provide frictional contact with turf fibers 19, thereby helping to hold fibers 19 in place. As a result of this layer, turf system 15 has improved binding characteristics and is less likely to experience premature fiber loss. It has been found that the use of third layer 24 increases the tuft bind of the system from nine to thirteen pound pull strength.

Pull strength is the strength required to pull a turf fiber 19 from the primary backing 16. In the preferred embodiment, layer 25 is a 100% polypropylene substrate having a weight of 3.6 oz./yd.^{2} with a polypropylene face fiber having a weight of 1.0 oz./yd.^{2}. The FLW® style 2473 manufactured by BP Carpet Backings, of 835 Shugart Rd., Dalton GA 30720, may be employed in the preferred embodiment.

Fourth layer 26 is a woven, 9 pick leno weave that assists in interlocking pieces or panels 36a-w of the turf together. Layer 26 assists in increasing the seam strength when panels of artificial turf 15 are sewn together to cover a large surface area 38. Fourth layer 26 acts as a web and provides a lateral grid across the surface, linking the edges of the panel of turf with the interior such that when panels are sewn together the seam is held from pulling free at the edges of the panel by the strength of layer 26. This creates a tight seam between adjacent portions of the turf field and reduces seam failure. In the preferred embodiment, layer 26 comprises 100% polypropylene tape yarn warp and 100% polypropylene spun yarn fill. The ActionBac® style 3869 material manufactured by BP Carpet Backings, of 835 Shugart Rd., Dalton GA 30720, may be employed in the preferred embodiment.

Fig. 4 shows the weave structure of layers 23-26. Layers 23-26 may be bonded together and a portion of fibers 19 assist in mechanically holding layers 23-26 together. As shown in Figs 2-3, back stitches 27 protrude slightly out from the bottom of fourth layer 26 and secondary backing 42 adheres to and coats back stitches 27.

Turf fibers 19 are tufted through primary backing 16 with a conventional three-eights of an inch ("3/8) gauge tufting machine having certain modifications. Fibers 19 are inserted by vertical, reciprocating needles positioned in a row across a fifteen foot wide conventional machine. Individual cones of fiber filaments are arranged in racks on the creel. A guide is provided for each filament coming from the creel, with a filament feeding each needle on the needle bar. From the creel the filaments pass through guides to the ribbon puller rolls of the tufting machine. Adjusting the speed of these puller rolls controls the amount of ribbon supplied to the machine and is a factor in determining the height of the tufted ribbon. The filaments then pass through a series of vertically aligned and fixed guides which direct the flow of the filament to the jerker bar, which controls the slack caused by the movement of the needles.

The filaments are then threaded through the respective needles in the needle bar. Each layer 23-26 of primary backing 16 into which fibers 19 are inserted is supplied in roll form, located in front of the tufting machine. Spiked rolls positioned on the front and back sides of the tufting machine draw the four layers 23-26 over the bed plate and through the machine. The speed of the spike rolls controls the stitches per inch. Moving the primary backing slowly through the machine produces more stitches per inch while a faster rate produces few stitches per inch longitudinally. The section between the creel and the tufting machine is modified to provide the correct number of rolls for each of the layers of primary backing 16.

In order to manufacture the preferred embodiment, certain other modifications to a conventional tufting machine were made. First, the conventional needles were placed with heavier, more rigid and more durable needles to allow for the needles to punch through layers 23-26. The 1457 RWS needles manufactured by Eisbar, of Germany, may be employed in the preferred embodiment. In addition, the conventional gear box was replaced with a more powerful exterior mounted gear box to allow for the machine to pull all four layers 23-26 under the correct tension. Finally, before the final tufting process, layers 24 and 25 are needle punched together. This facilitates the feeding of all four layers 23-26 through the tufting machine at the same time. The speed of the spiked rolls and the numbers of needles on the needle bar are modified to provide the equal spacing between the rows and columns of ribbon 17 of about three-eighths of an inch ("3/8).

Located below the bed plate are the looper and knife combination for the pile cut employed in the preferred embodiment, with the lopper and knife holding and cutting the fiber filaments in a single operation. The loppers are of a reversed-C shape, with a cutting surface on the top inside edge of the crescent. The loppers are used in combination with knives having a ground cutting edge on one end. As primary backing 16 advances through the machine toward the loopers, the fiber filaments picked up from the needles are cut by the scissor-like action between the looper and the knife.

Two biomechanical properties of the preferred embodiment were tested and measured: the ability of the surface to reduce impact forces associated with landing on the surface, also referred to as cushioning, and the ability of the surface to provide frictional support at the interface between a sports shoe and the surface, also referred to as traction.

These properties are relevant because excessive impact forces, from running or falling, can have a negative effect on a player using the playing surface. The frictional aspects of the surface are also relevant and generally break down into translational and rotational friction. Ideally, the friction between the turf surface and the player's athletic shoe should be at a level high enough to avoid slipping, thereby providing for optimum performance, such as fast acceleration and quick directional changes, while being at a level low enough to limit injuries.

The preferred embodiment was tested by mounting samples on a thin aluminum plate that was bolted to a force platform designed to measure and record all relevant data. Data was sampled at a frequency of 1000 Hz for the cushioning and rotational friction tests and 100 Hz for the translational friction test. A workstation recorded the force data from the force platform and the data was analyzed using conventional software. A representative standard Adidas® Supernova running shoe and a representative Nike® Roma FT cleated soccer shoe were used as the subject footwear.

Vertical drop tests were performed using masses of 4 kg and 7.3 kg. Five trials at heights of 5, 10 and 20 cm, respectively, were performed with both of the masses. Peak impact forces (F_{zmax}) were recorded and averages determined. The height and masses were chosen to simulate typical impact forces that might occur on the sporting surface. The impact loading rate was calculated by dividing the peak impact force by the time necessary to reach the peak. Table 1 shows the measured impact results for the preferred embodiment.

Table 1. Vertical drop test mean and standard deviation impact peak results (cushioning) from the surface.

	F_{zmax}[N]					
Mass [kg] Height [cm]	4 5	4 10	4 20	7.3 5	7.3 10	7.3 20
Trial 1	434	746	1146	673	1114	1920
Trial 2	410	768	1359	596	1110	2449
Trial 3	480	627	1552	720	1158	1904
Trial 4	515	619	1080	690	1080	2290
Trial 5	510	703	1151	550	1092	1998
Average	475	693	1219	653	1105	2069
Std. Dev.	38	60	122	50	12	195

Table 2 shows the impact loading rates results for the preferred embodiment.

Table 2. Vertical drop test mean and standard deviation impact loading rate results from the surface.						
	Max Loading Rate [kN/s]					
Mass [kg] Height [cm]	4 5	4 10	4 20	7.3 5	7.3 10	7.3 20
Trial 1	21.7	57.4	81.9	39.6	65.5	137.1
Trial 2	22.8	59.1	113.3	28.4	65.3	204.1
Trial 3	32.0	39.2	141.1	45.0	72.4	119.0
Trial 4	36.8	41.3	83.1	38.3	67.5	176.2
Trial 5	34.0	54.1	88.5	26.2	64.2	124.9
Average	29.6	50.9	95.0	35.4	66.1	146.1
Std. Dev.	6.0	8.5	16.1	6.1	1.2	26.8

Live impact testing was also performed on the preferred embodiment. Five subjects with a mean age of 22.8 years, a mean height of 1.79 meters and a mean mass of 74.4 kg, ran heal to toe style at a velocity of 4 m/s - 0.4 m/s with the right foot making full contact with a turf sample affixed to the force platform. Running velocity was measured. Five trials were performed for which impact peaks (F_{zmax}) were recorded. The impact loading rate was calculated by dividing the peak impact force by the time necessary to reach the peak. Table 3 shows the live impact test results.

Table 3. Mean and standard deviation of the maximal vertical impact forces, F_{zmax}, and impact loading rates.						
Subject		1	2	3	4	5
Force (N)	Trial 1	1805	1041	1073	1218	1048
	Trial 2	1632	1159	953	1225	1189
	Trial 3	1834	1219	1049	1159	852
	Trial 4	1743	1074	1428	1288	876
	Trial 5	1637	962	1363	1427	981
	Average	1728	1091	1162	1244	1002
	Std. Dev.	85	61	175	39	40
Loading Rate (kN/s)	Trial 1	50.1	26.0	25.5	38.1	55.2
	Trial 2	41.8	36.2	23.8	36.0	54.0
	Trial 3	48.3	42.0	31.8	36.2	30.4
	Trial 4	43.6	29.8	33.2	39.0	32.5
	Trial 5	42.0	25.3	31.7	40.8	46.7
	Average	44.6	30.7	29.7	37.8	44.4
	Std. Dev.	3.3	5.2	3.6	1.4	10.9

Translational friction testing was performed using a cart consisting of a weighted sled attached to a sport shoe. The cart was placed over the sample such that only the sole of the shoe came in contact with the sample surface and, as the cart was pulled, the shoe was dragged across the surface while the force platform measured the vertical and horizontal loads. The coefficient of friction for the surface was determined from:

$$\mu = \frac{F_h}{F_v}$$

μ = coefficient of friction
F_h = horizontal or frictional force
F_v = vertical or normal force.

Trials were performed with a mass of 12.5 kg and the average of the dynamic frictional coefficient was calculated using the three middle values. The results of the test for the two subject test shoes are set forth in Tables 4 and 5, respectively.

Table 4. Mean and standard deviation of maximal free moment of rotation, M_{max}, and translational friction coefficients for the Adidas Supernova running shoe.

	Running Shoe Trans. Friction Coeff. (u) Direction 1	Direction 2
Trial 1	0.69	0.94
Trial 2	0.79	0.83
Trial 3	0.82	0.81
Trial 4	0.83	0.76
Trial 5	0.80	0.77
Average	0.80	0.88
Std. Dev.	0.02	0.03

Table 5. Mean and standard deviation of maximal free moment of rotation, M_{max}, and translational friction coefficients for the Nike soccer shoe.

	Soccer Boot Trans. Friction Coeff. (u) Direction 1	Direction 2
Trial 1	1.64	1.50
Trial 2	127	1.21
Trial 3	1.18	1.14
Trial 4	1.13	1.10
Trial 5	1.12	1.16
Average	1.19	1.17
Std. Dev.	0.07	0.04

Rotational friction was also determined with live subjects. Each of five subjects stood on the ball of their right foot and made a full 180° turn on the surface. The rotational friction is directly proportional to the maximum vertical free moment of rotation (M_{max}) which was measured using the force platform. The vertical free moment of rotation (M_{max}) was recorded for the five trials and an average of the three middle trials was calculated. High moments of rotation correspond to high resistance against rotation. The results from the tests are set forth in Table 6.

Table 6. *Rotational Friction (Nm)*

Subject Shoe Type	1 Running	1 Soccer	2 Running	2 Soccer	3 Running	3 Soccer	4 Running	4 Soccer	5 Running	5 Soccer
Trial 1	22.0	32.8	26.2	29.2	18.3	23.4	32.2	41.1	16.5	18.5
Trial 2	29.9	33.0	24.3	28.9	22.8	26.0	33.3	44.0	13.5	21.5
Trial 3	28.0	36.0	25.8	29.6	24.0	31.1	36.1	43.8	18.0	23.7
Trial 4	26.5	34.2	24.2	23.6	19.4	25.2	30.4	44.0	14.7	19.6
Trial 5	20.5	33.4	28.6	37.2	18.3	20.8	31.2	42.2	17.7	22.7
Average	25.5	33.5	25.4	29.2	20.2	24.9	32.2	43.3	16.3	21.3
Std. Dev.	3.1	0.6	1.0	0.4	2.3	1.3	1.1	1.0	1.5	1.6

The above results indicated that the preferred embodiment was highly recommended for both cushioning and friction properties, the highest available ranking.

Figs. 5-6 show an alternate embodiment 28 of the turf system shown in Fig. 1. This first alternate embodiment 28 is similar to turf system 15 in all respects except that it has an infill 29. Infill 29 is made up of 70% granular ambient rubber particles from recycled tires and 30% kiln dried sand particles 31. Rubber 30 is washed after processing and is substantially free of metal particles. In this embodiment, the mesh size of granular rubber 30 is between 8 and 16 with a specific gravity of 1.13 to 1.27. Sand 31 is clean, dry, rounded silica sand and has a mesh size between 20 and 40. Infill 29 is mixed prior to application to ensure consistency and uniformity.

Figs. 7-9 show a third embodiment 32. Embodiment 32 is the same as second embodiment 28 in all respects except that the primary backing 33 does not include layer 23. Rather, as shown in Figs. 8-9, primary backing 33 is made up of three layers, rather than four. In particular, primary backing 33 is made up of layers 24, 25 and 26, with layer 24 being the top layer, layer 25 being the middle layer, and layer 26 being the bottom layer.

Secondary backing 18 is applied to the bottom surface of layer 26 as in the preferred embodiment.

Figs. 10-12 show a fourth embodiment 34. Embodiment 34 is the same as third embodiment 32 in all respects except that the primary backing 35 is made up of two layers, rather then three layers. In particular, primary backing 35 is made up of layers 25 and 26, with layer 25 being the top layer and layer 26 being the bottom layer.

Fig. 13 shows panels of turf 28 arranged to provide a playing surface 38 for a football field. Playing surface 38 is formed by a series of laterally extending rectangular sections or panels 36a-w. As shown in Fig. 13, in order to provide a uniform playing surface, each of panels 36a-w is connected to at least one adjoining panel at seams 40a-u.

Fig. 14 shows a lapp sewn seam known in the prior art. As shown in Fig. 14, in the prior art, in order to assure that stitching 43 did not pull out from the edges of the two adjoining panels, an excess portion 42 of primary backing 41 was left to provide support for seam 43.

In contrast, Fig. 15 shows a seam employed with turf 28. As shown, because of the additional strength and stability of primary backing 16, additional leftover backing material 42 is not needed to hold stitching 45 in place. Rather, stitching 45 is looped through primary backing 16 in panels 36a and 36b. Layer 26 has lateral strength at the edges of 36a and 36b, respectively, so that stitching 45 does not pull out from such edges. This allows the edges of primary backing 16 and secondary backing 18 of panels 36a and 36b to abut directly against each other. Thus, in contrast to the prior art shown in Fig. 14, no excess material is located between secondary backing 18 and base 22. This allows for a neat and even butt seam 40a, which in turn provides a flatter and more even playing surface 38. The 81500T turf sewing machine manufactured by Textile and Industrial Sales Inc., of 404 Whitener Drive, Dalton, GA 30722-0768, may be used in the preferred embodiment to sew stitching 45.

Fig. 16 is a bottom view of butt seam 40a with the addition of seam tape 46. As shown in this view, panels 36a and 36a abut each other at seam 40a. Stitching 45 is used to connect the abutting edges of panels 36a and 36b. Once loop stitching 45 has been sewn, seam tape 46 may be applied over the stitching to provide protection for the stitching and to add additional strength to seam 40a. Again, as shown in Fig. 16, because excess portions

of primary and secondary backing 16 and 18 are not necessary to hold stitching 45 in place due to the strength characteristics of primary backing 16, seam tape can be applied over the stitching 45 as shown. The Turf-lock seam tape manufactured by Turfstore.com Inc., of 237 Boling Industrial Way, Calhoun GA 30701, may be employed in the preferred embodiment.

The present invention contemplates that many changes and modifications may be made. Therefore, while the presently preferred form of the turf has been shown and described, and several modifications and alternate embodiments discussed, persons skilled in this art will readily appreciate that various additional changes and modifications may be made without departing from the spirit of the invention, as defined and differentiated by the following claims.